The Importance of Identifying and Quantifying Fish Behaviors to Predict the Migration Rate of Juvenile Salmonids

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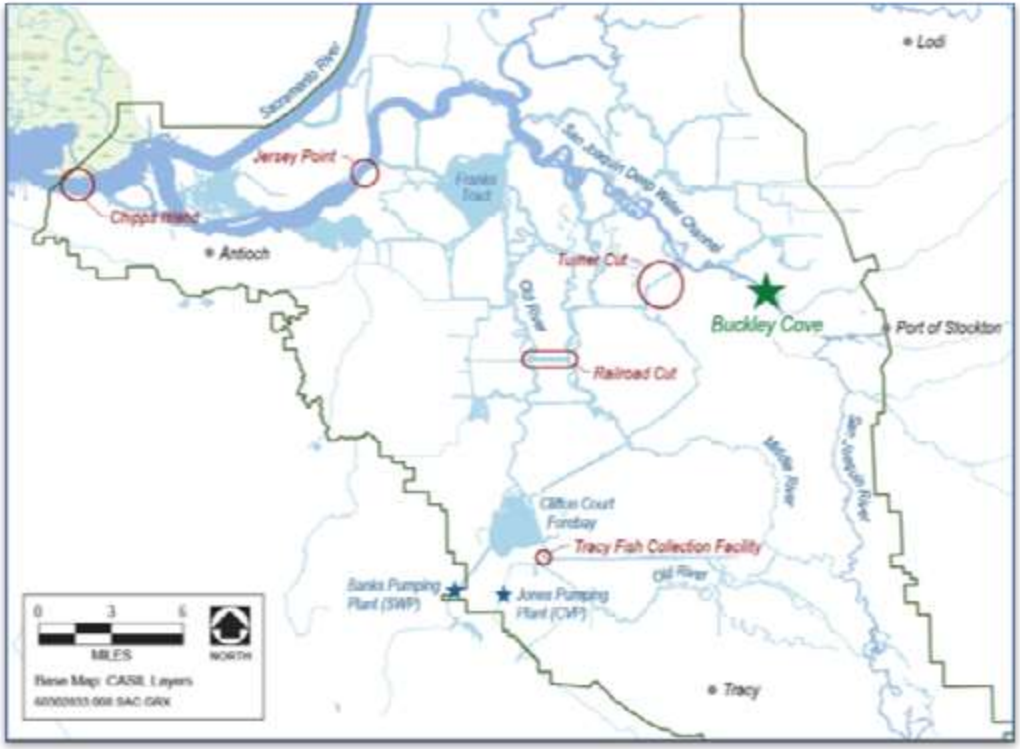
Introduction

- Particle or fish?
  - It has been hypothesized that the movement of simulated neutrally buoyant particles can act as an index of the movement of juvenile anadromous fish.
- Fish behaviors
- Coupled bio-physical models

Source: http://freelargephotos.com/photos/002666/large.jpg

Outline

- Data sources:
  - Tagging study
  - DSM2 particle tracking model (PTM)
- Examine the accuracy of the DSM2 PTM
- Identify important fish behaviors that influence fish movement

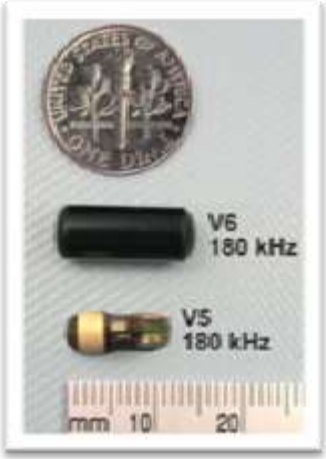


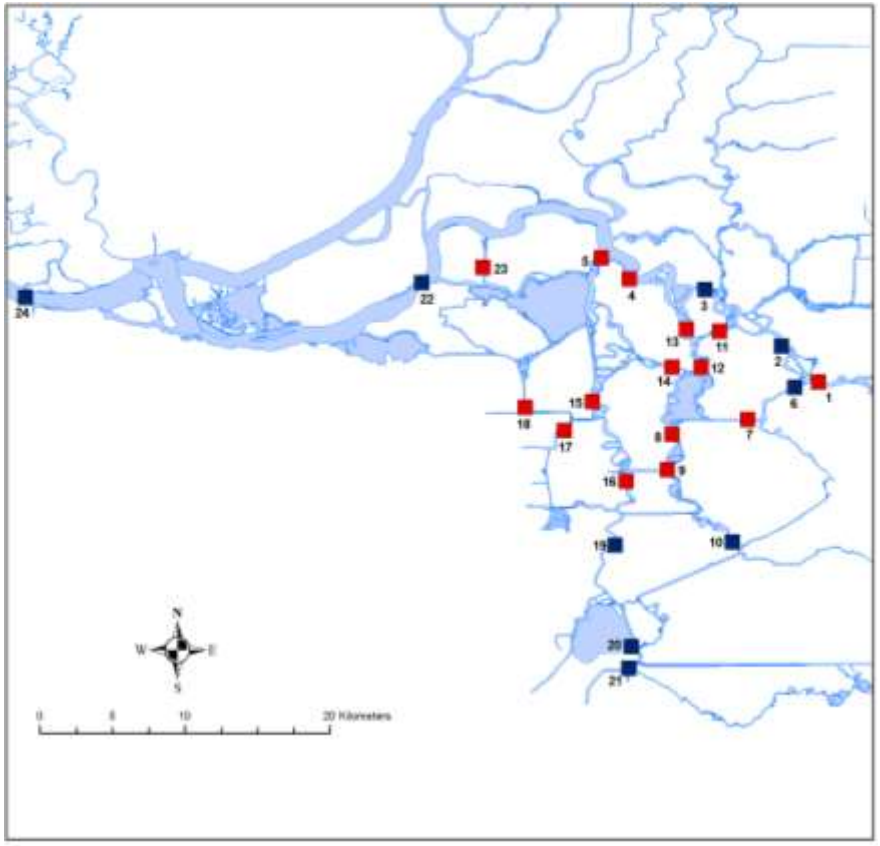
Tagging Study

- 501 acoustically tagged juvenile steelhead released at Buckley Cove in the spring of 2012

- Transmitters (tags):
  - VEMCO model V6

- Receiver arrays deployed for the Stipulation Study (red squares) and Six-Year Study (dark blue squares)



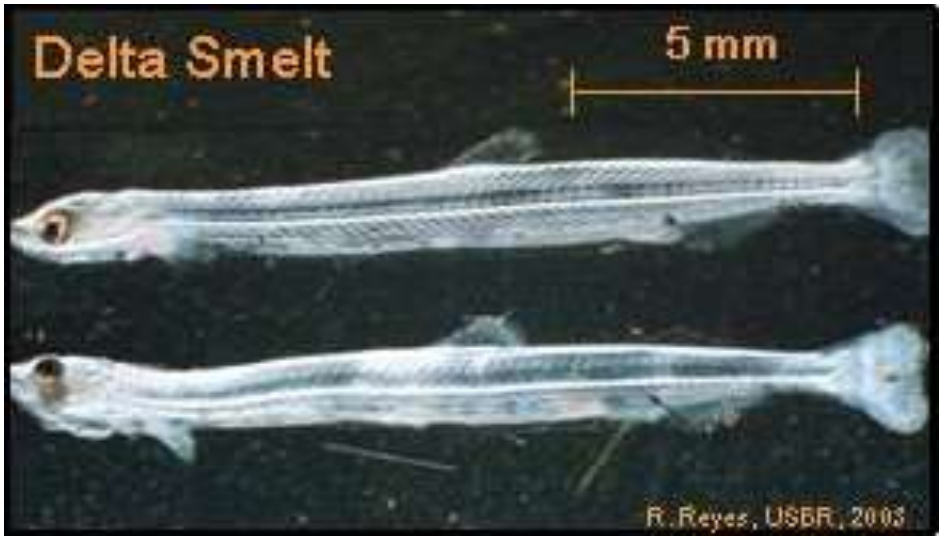


DSM2 Hydro Particle Tracking Model

- Effects of various barriers
  - Head of Old River Barrier
  - Delta Cross Channel Gates
- Entrainment
  - Agricultural diversions
  - Export facilities
- Identifying actions to conserve species
  - 2008 OCAP BA
  - 2009 OCAP BO

Can the purely physical PTM predict the movement of steelhead?

- Null hypothesis:
  - The distance traveled by steelhead tags was not significantly different than the distance traveled by particles.

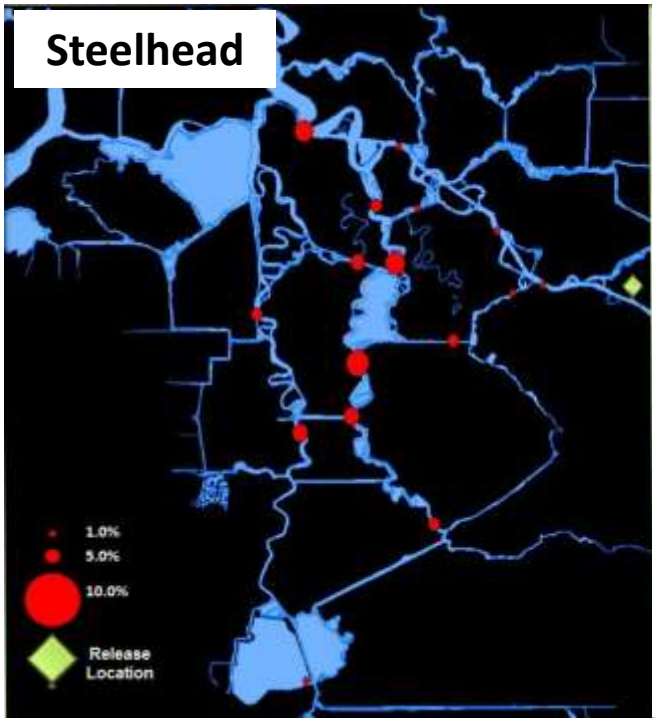


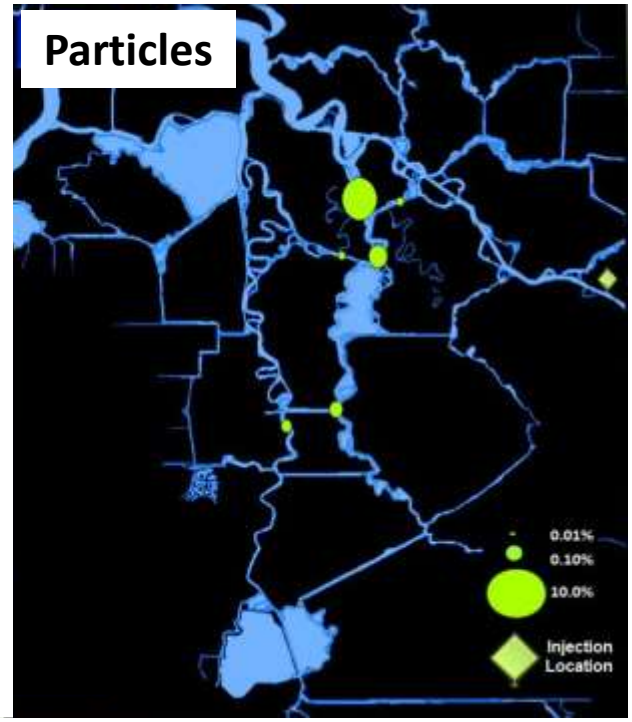
Source: http://www.dfg.ca.gov/delta/data/nba/NorthBayAqueduct.asp

Oncorhynchus mykiss

Can the purely physical PTM predict the movement of steelhead?

- Approach:
  - Distance traveled 3 and 7 days after release
  - Euclidean distance
  - Each day analyzed with a t-test

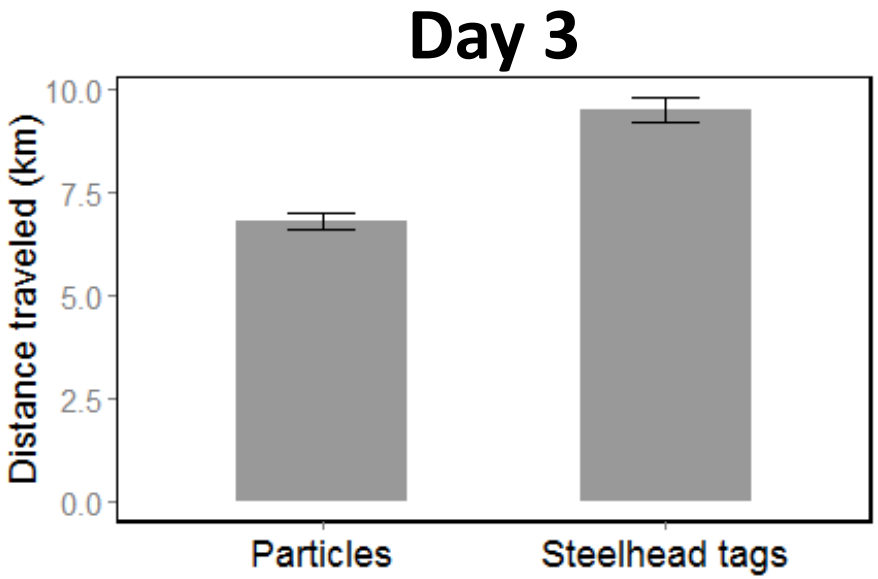




Results for comparing particle to tag data

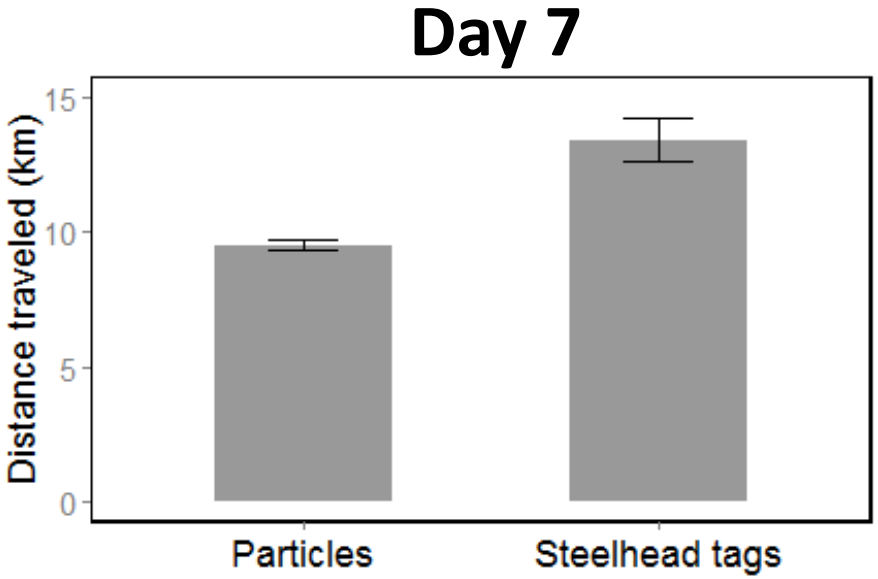
Day 3 :

- Particles only traveled 71.6% of the distance traveled by steelhead
- $P < 0.01$

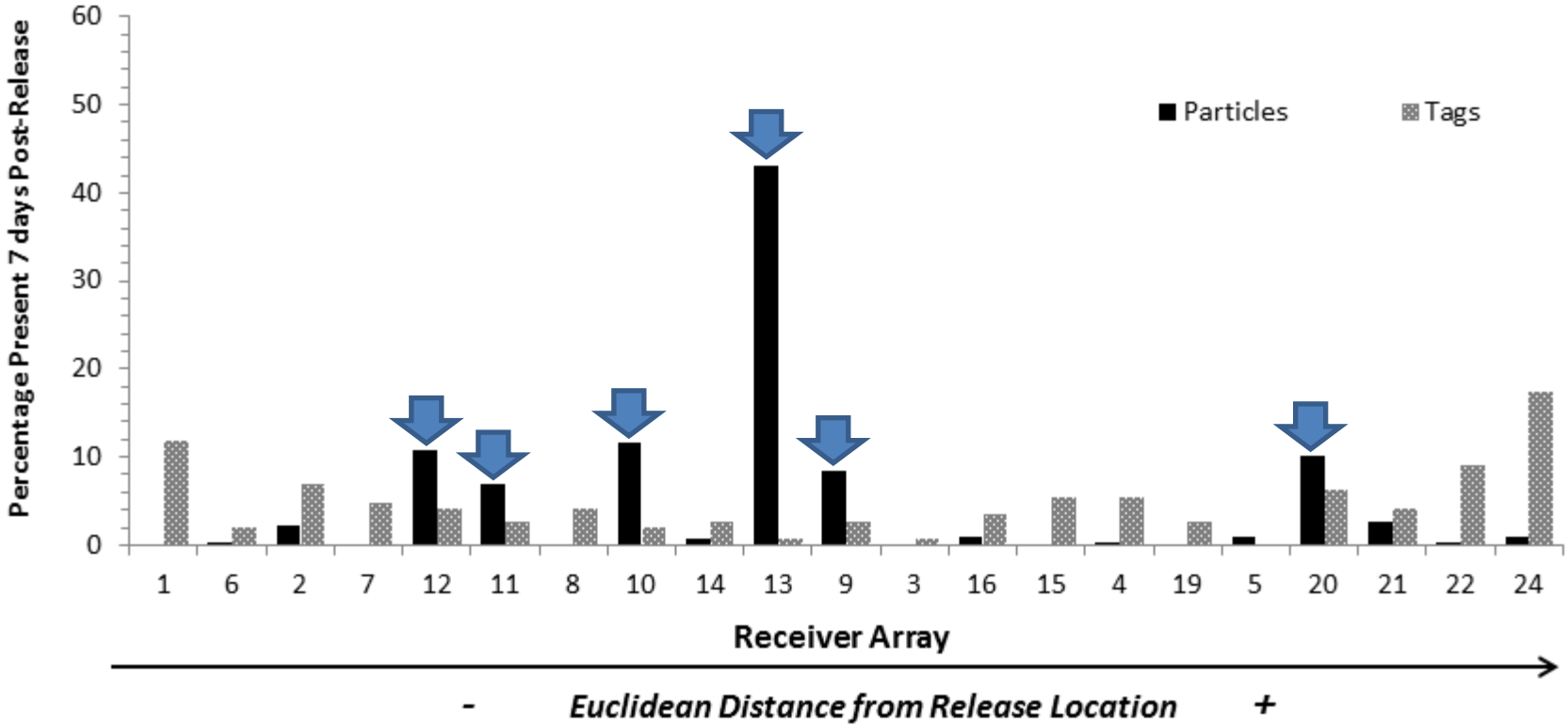


Day 7:

- Particles only traveled 70.9% of the distance traveled by steelhead
- $P < 0.01$



Results for Day 7



Selective Tidal-Stream Transport (STST): Are steelhead “tidally surfing”?

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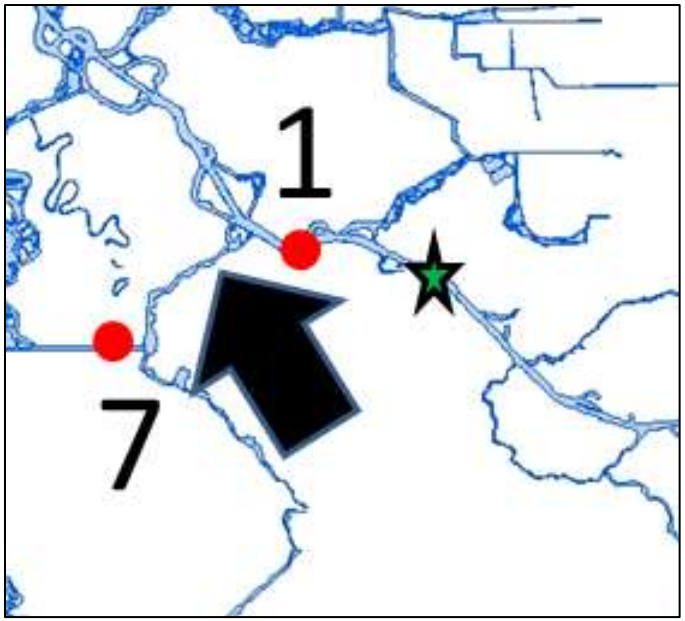
To examine this, we calculated φ with the following equation:

$$\varphi = (U-V) / (\textit{RMS tidal velocity})$$

- φ = contribution of STST behavior to migration
- U is the mean velocity of steelhead tags
- V is the mean velocity of particles
- RMS tidal velocity

Interpreting what values of φ mean:

- If $\varphi = 0$: passive drift
- If $0 < \varphi < 0.5$: limited STST
- If $\varphi = 0.5$: optimal STST
- If $\varphi > 0.5$: active, directed swimming



= location of CDEC station

= location of an array

= location of release site

Interpreting results of the STST analysis

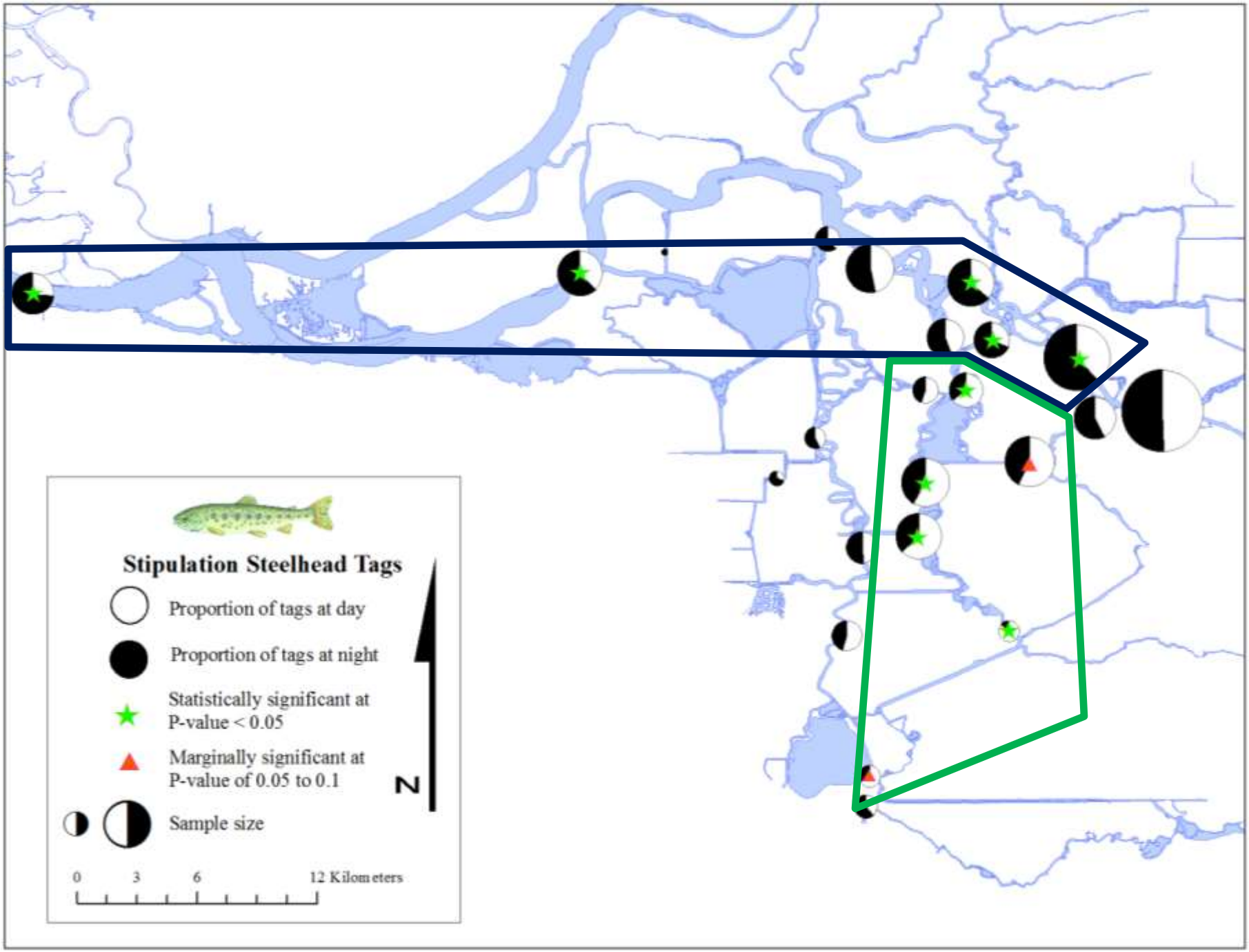
- We found that φ was 0.39
- Limited STST
  - Most likely explanation:
    - STST movement occurs during only part of flood tide and/or that the smolts move into low velocity, but not zero-velocity areas on the flood tide.

Source: http://e-uhs.efxinternet.com/admin/Image Library/Forms/AllItems.aspx

Is steelhead movement random or is it related to daytime or nighttime?

- Null hypothesis:
  - The movement of steelhead tags in the San Joaquin River and interior Delta was random (*i.e.,* not related to day/night).
- Approach:
  - The proportion of tags first detected during day or night
  - Binomial tests were conducted at each array

Source (top): http://www.wallpapersshop.net/wallpapers/2012/12/Cannot-Fish-Blue-Sun.jpg
Source (bottom): Modified version of pictures from http://www.mainlinemedianews.com /articles/2012/11/29/main_line_times/life/doc50b6f03922e37916448820.txt and http://www.fish.wa.gov.au/species/rainbow-trout/Pages/default.aspx

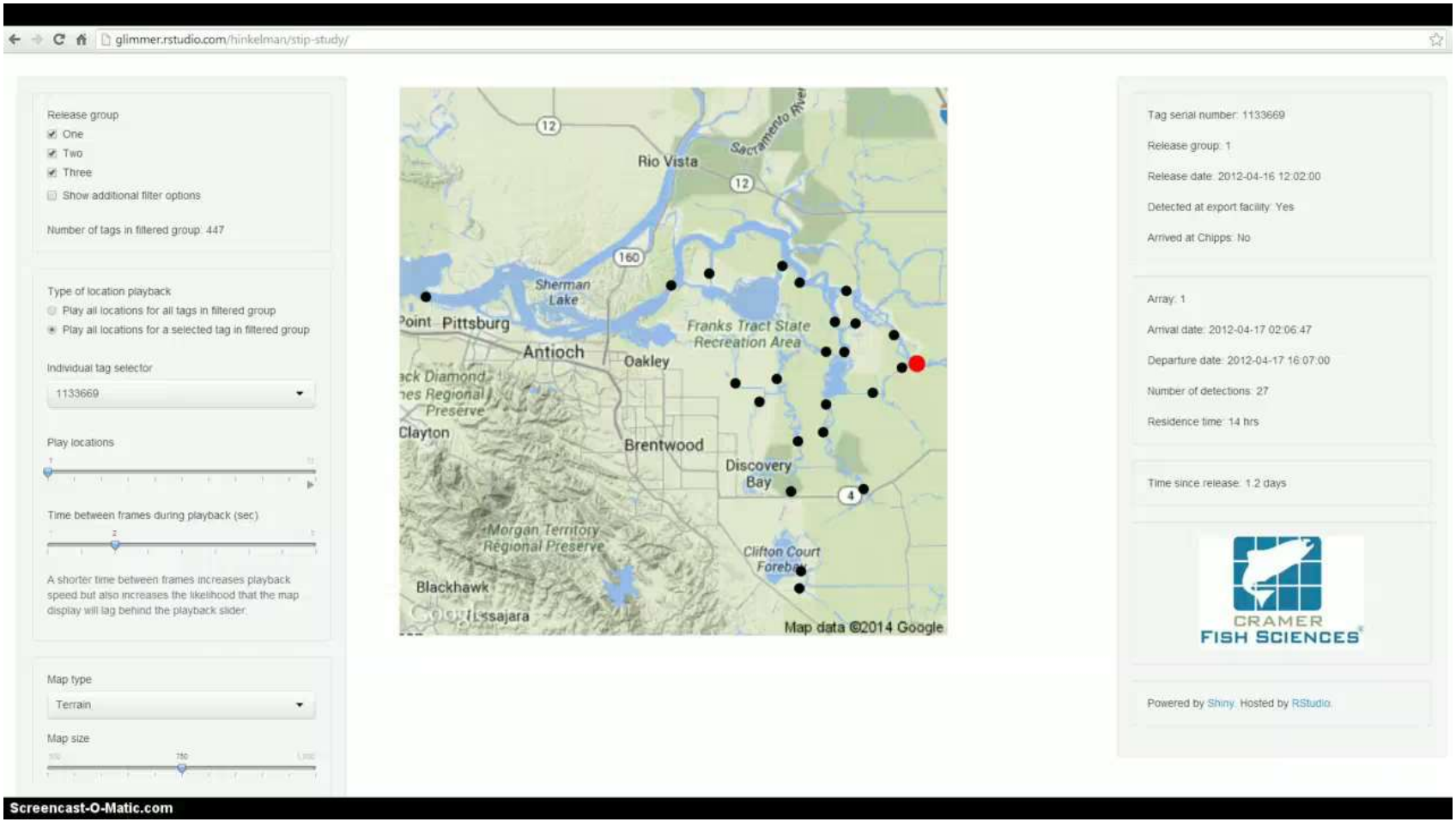

Stipulation Steelhead Tags
Proportion of tags at day
Proportion of tags at night
Statistically significant at
P-value < 0.05
Marginally significant at
P-value of 0.05 to 0.1
Sample size
N
0
3
6
12 Kilometers

Questions for future studies

- What explains the day/night patterns?
- Do STST behaviors of steelhead vary between day and night?
- Do STST behaviors of steelhead vary spatially across the Delta?
- What behaviors need to be incorporated into coupled bio-physical models?

Source: http://freelargephotos.com/photos/000524/large.jpg

Web-based tool to display acoustic telemetry data: http://glimmer.rstudio.com/hinkelman/stip-study/



Conclusions

- The purely physical model did not accurately predict the movement of steelhead
- Juvenile steelhead seemed to be exhibiting behaviors
- We need to identify, quantify, and incorporate the important behaviors
- Validation of coupled bio-physical models is essential

Source: http://www.adammandelman.net

Report available at:

http://www.fishsciences.net/email/va01/Stipulation_Study_Report.pdf

Acknowledgements:

Agencies

Consultants


Questions?